Discussion with EPP2010

Pier Oddone

January 23, 2005

Various possible topics

- How to capture the ILC: do we maximize the integral probability or the probability of the “golden moment”?
- Fermilab neutrino program in the international context
- Transition at Fermilab: focus, alignment, national involvement, internationalism
- Character of Fermilab in the era of ILC
- WHAT IF: no ILC
- Any topics of interest to the committee

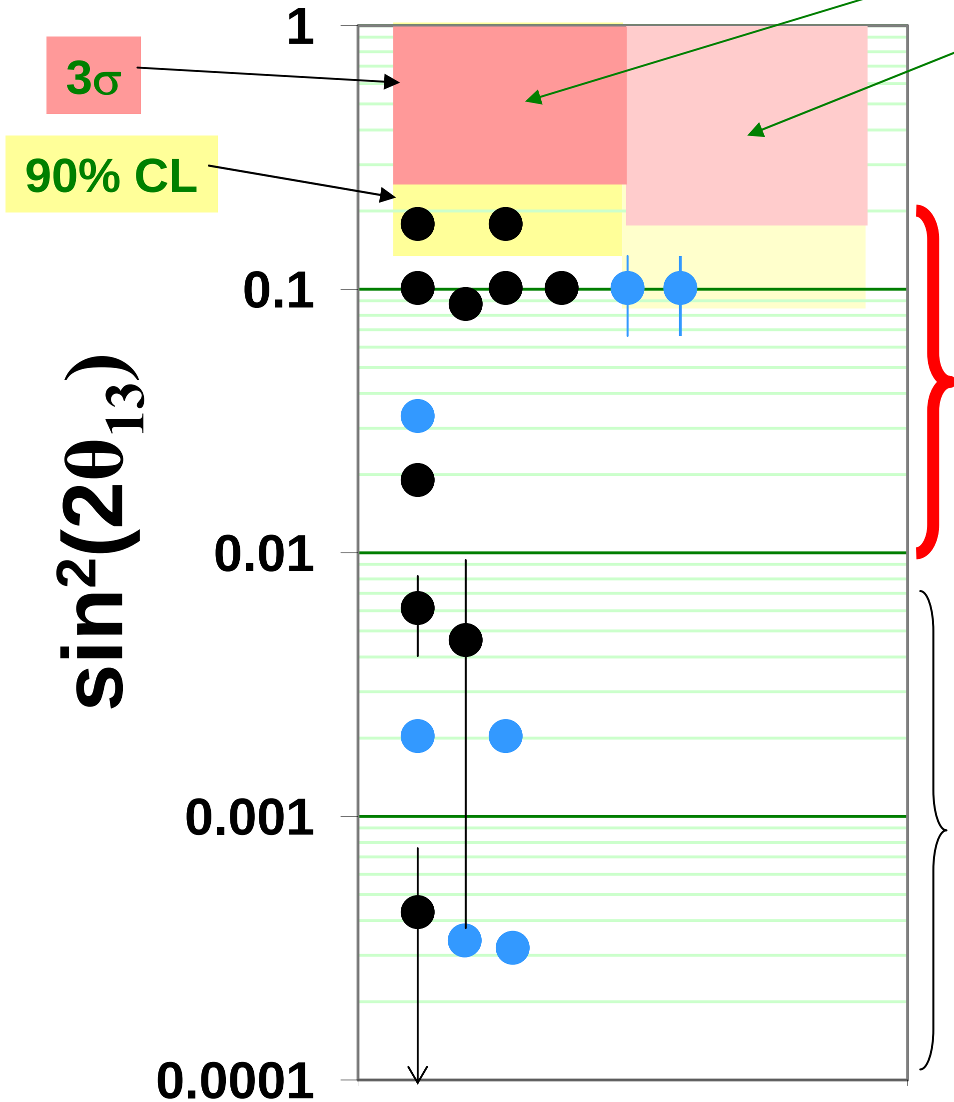
Topic II

Fermilab neutrino program in the international context

Accelerator neutrino program

- Gateway parameter $\sin^2 2\theta_{13}$
- Reactors measure only this parameter
- Accelerator program is richer: measurement of $\sin^2 2\theta_{13}$,Mass hierarchy, CP δ, Δm^2_{32}, $\sin^2 2\theta_{23}$
- Two main players in the near future: JPARC/T2K, MI/NOVA together with reach into all these parameters

Theory Model Predictions for $\sin^2(2\theta_{13})$



CHOOZ + ATM + K2K

Global fit
with solar + 2004 KamLAND
(these limits from
Maltoni,Schwetz,Tortola,& Valle
hep-ph/0405172)

About factor of 10 within NOvA/T2K/reactor reach

7 too small for all proposals

● **from Albright 2004**

● **From Minakata hep-ph/0505262**

A global program

- Reactor experiment: get $\sin^2 2\theta_{13}$ and stop

- T2K: detector built, accelerator under construction – no reach into the mass hierarchy in the initial phase

- NOVA: accelerator is built but the simple part, the detector, is missing! Reach into the mass hierarchy

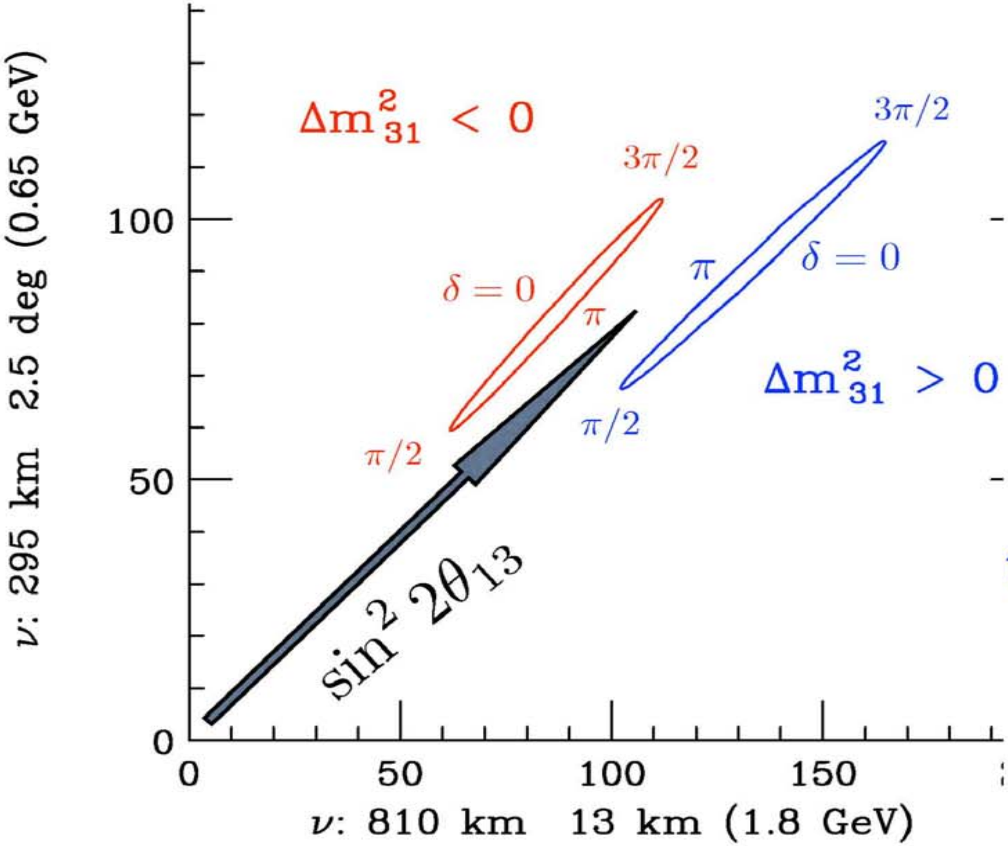
Will distinguish following phases:

- Initial
  - NOVA at 30 ktons; MI at 0.7MW
  - T2K with SK and JPARC at 0.7-1.3MW
- Intermediate
  - NOVA with 20 ktons more; MI at 1.1 MW; 1.3 times running time (equivalent to NOVA at 30 ktons with proton driver at 2.4 MW and 1.0 running time)
  - T2K at 4MW but no Hyper-detectors
- Final
  - Intermediate stage as above, with Hyper K (Kamioka) or Hyper KK (Kamioka+Korea)

Combined approach

- Illustrate the program by using SK as the "near" detector and NOVA as the "far" detector in a combined program
- Use 5 year neutrino running
- Distinguish the three phases: initial, intermediate and final

Neutrino-Neutrino Comparison:

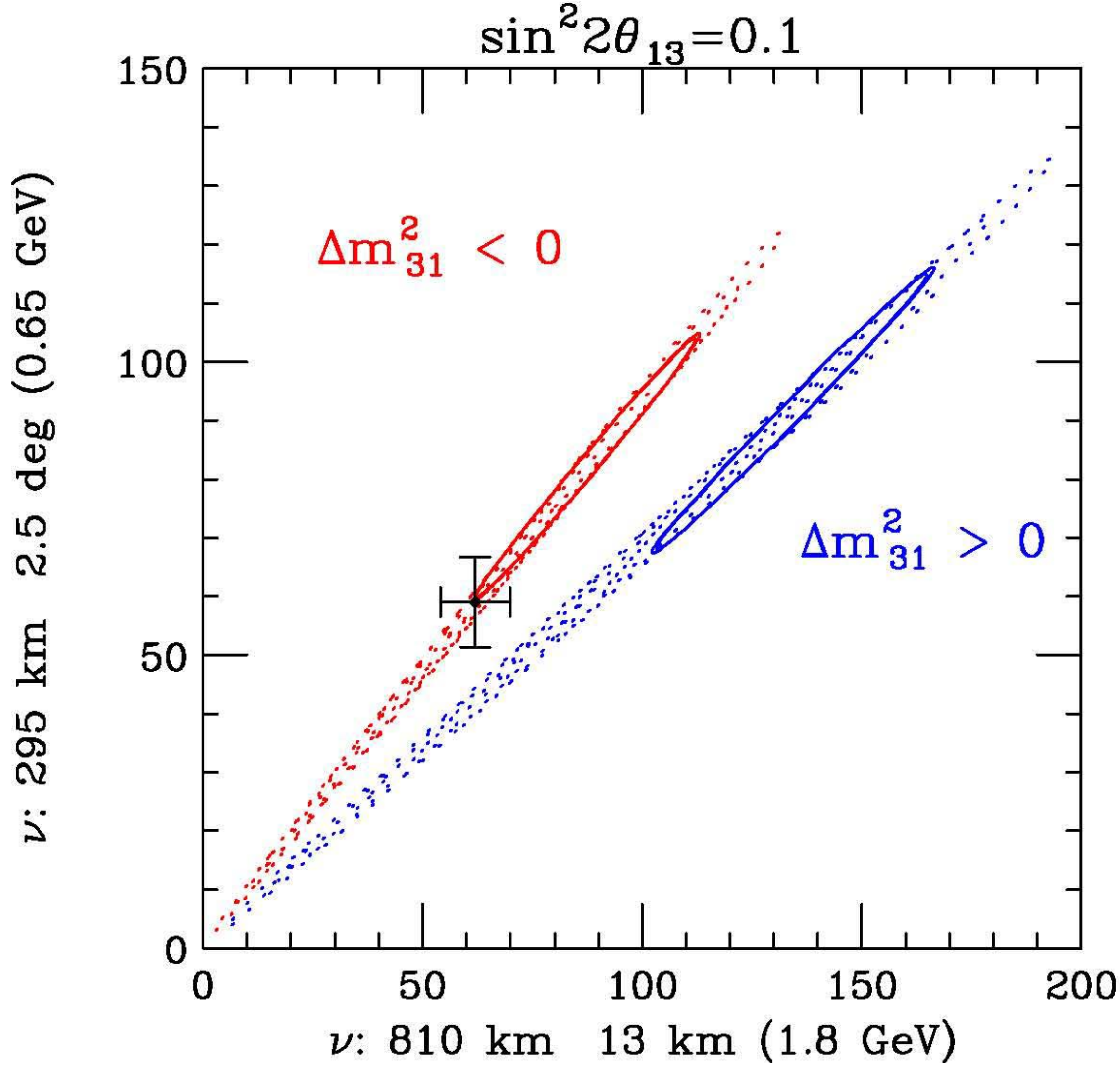


Ellipses flatten as the (E/L)'s become identical.

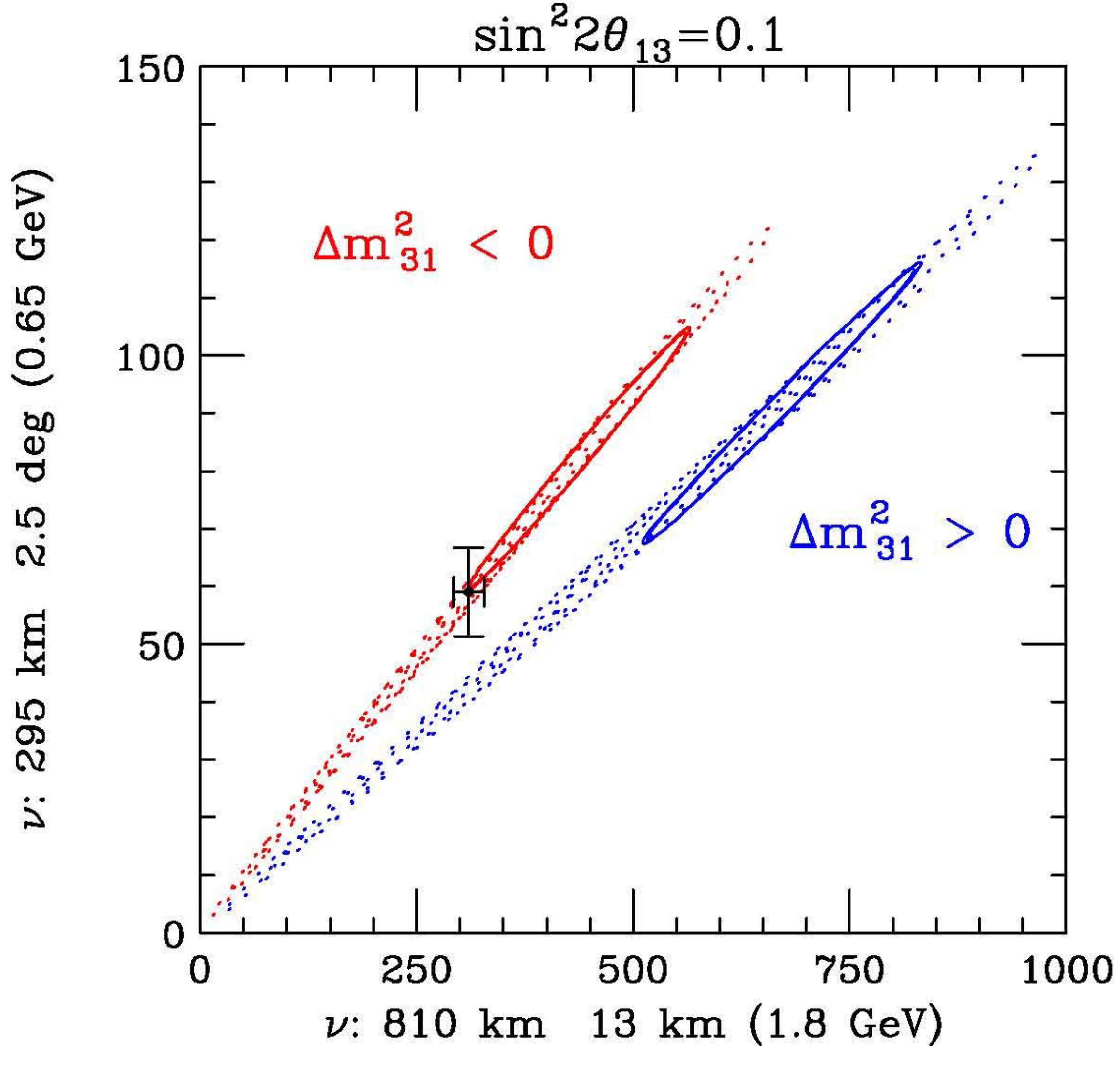
Horiz. separation caused by matter effect for NOvA, the smaller Vert. separation by matter effect for T2K.

It is IMPORTANT that the matter effects are significantly different for the two experiments.

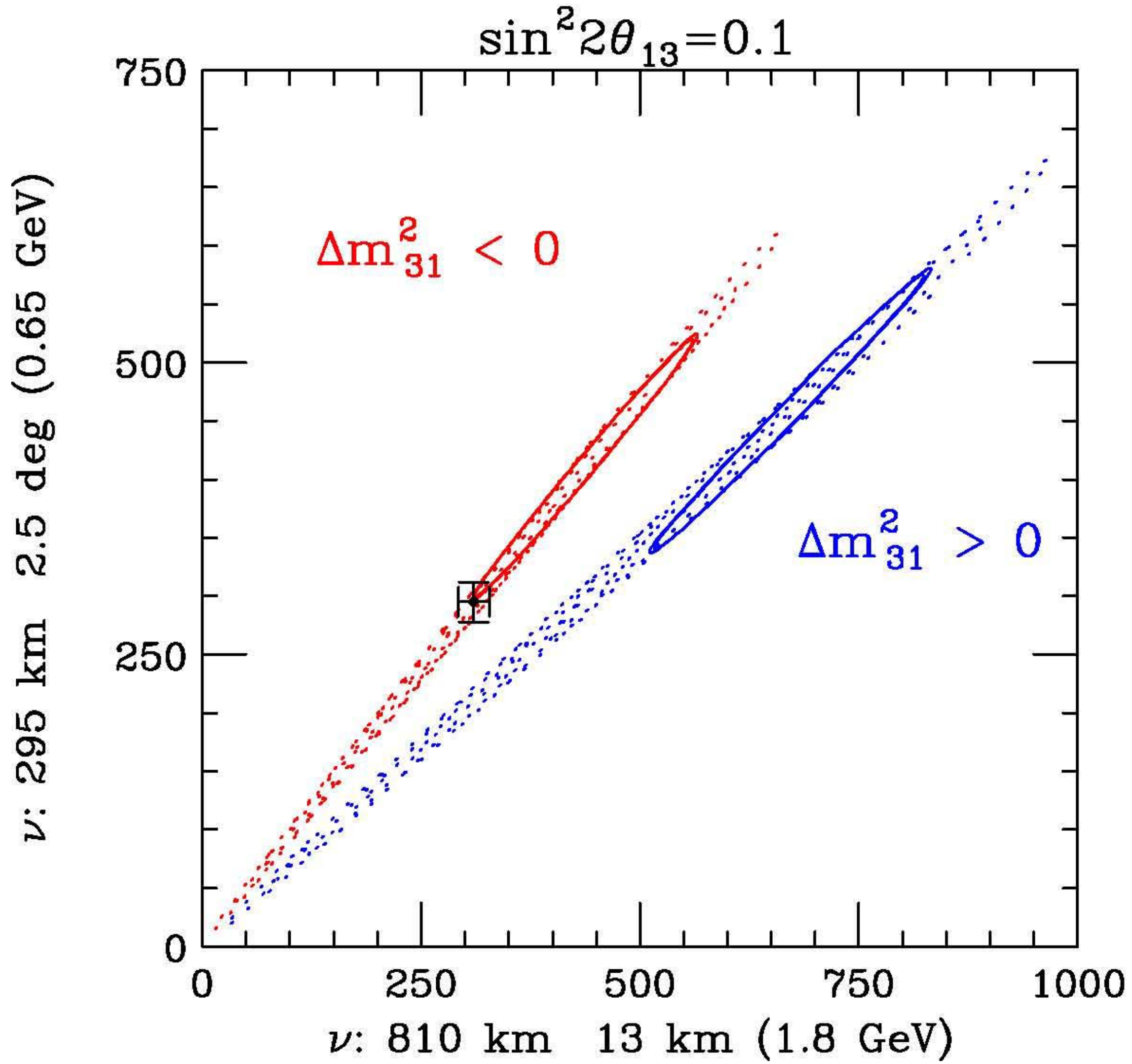
EVENTS T2K (initial) vs. NOVA (initial)



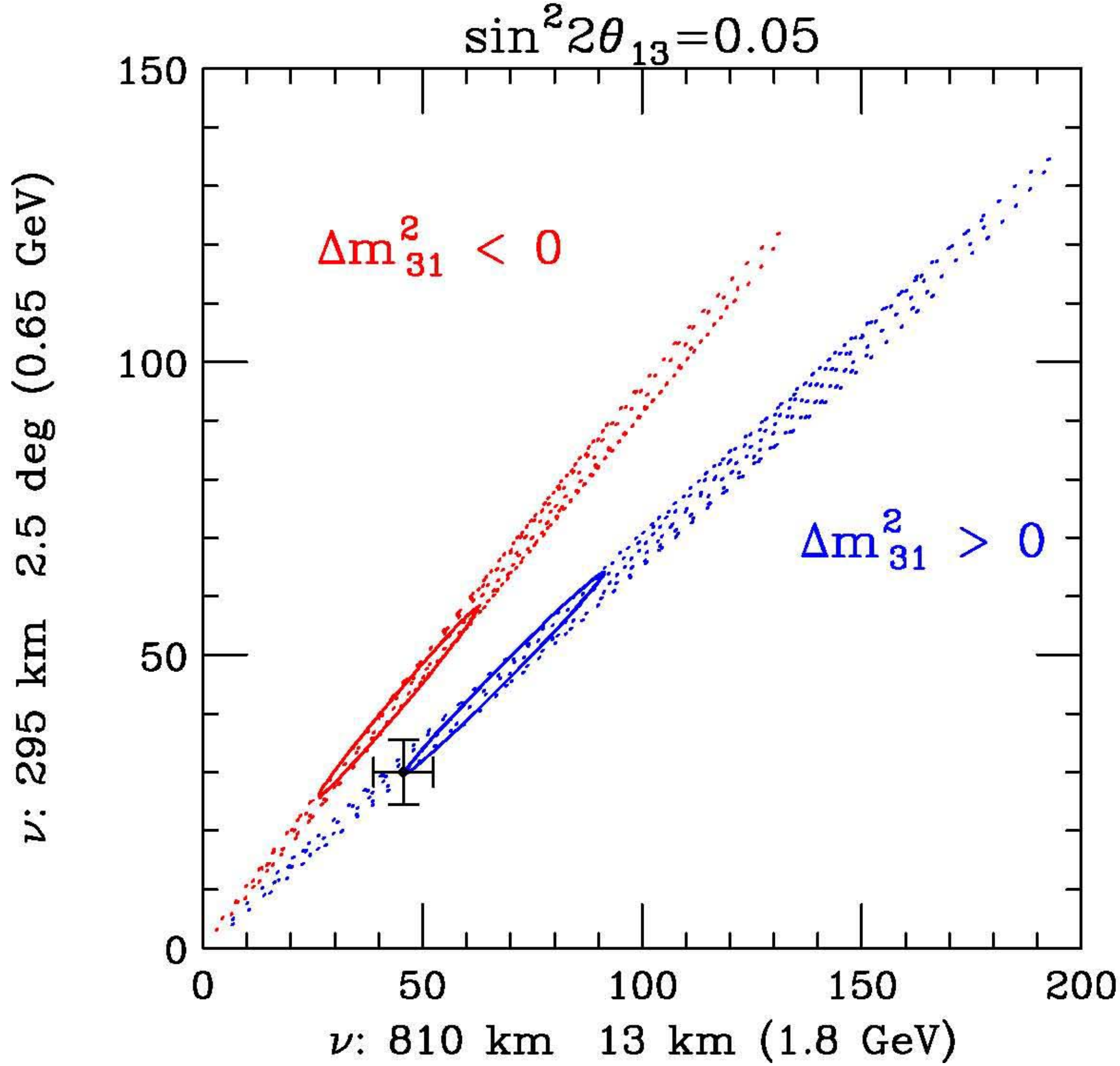
EVENTS T2K (initial) vs. NOVA (intermediate)



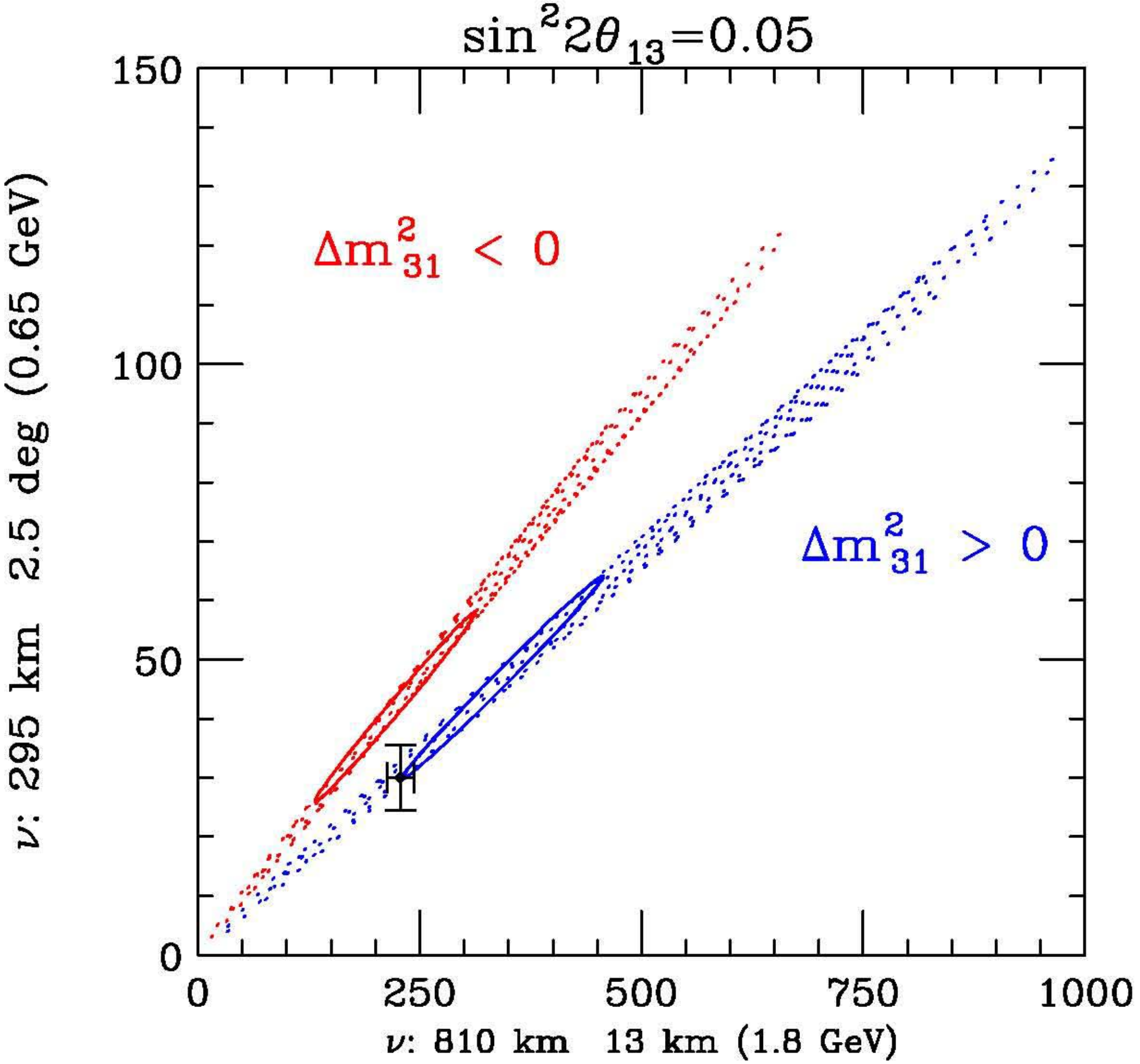
EVENTS: T2K (intermediate) vs. NOVA (intermediate)



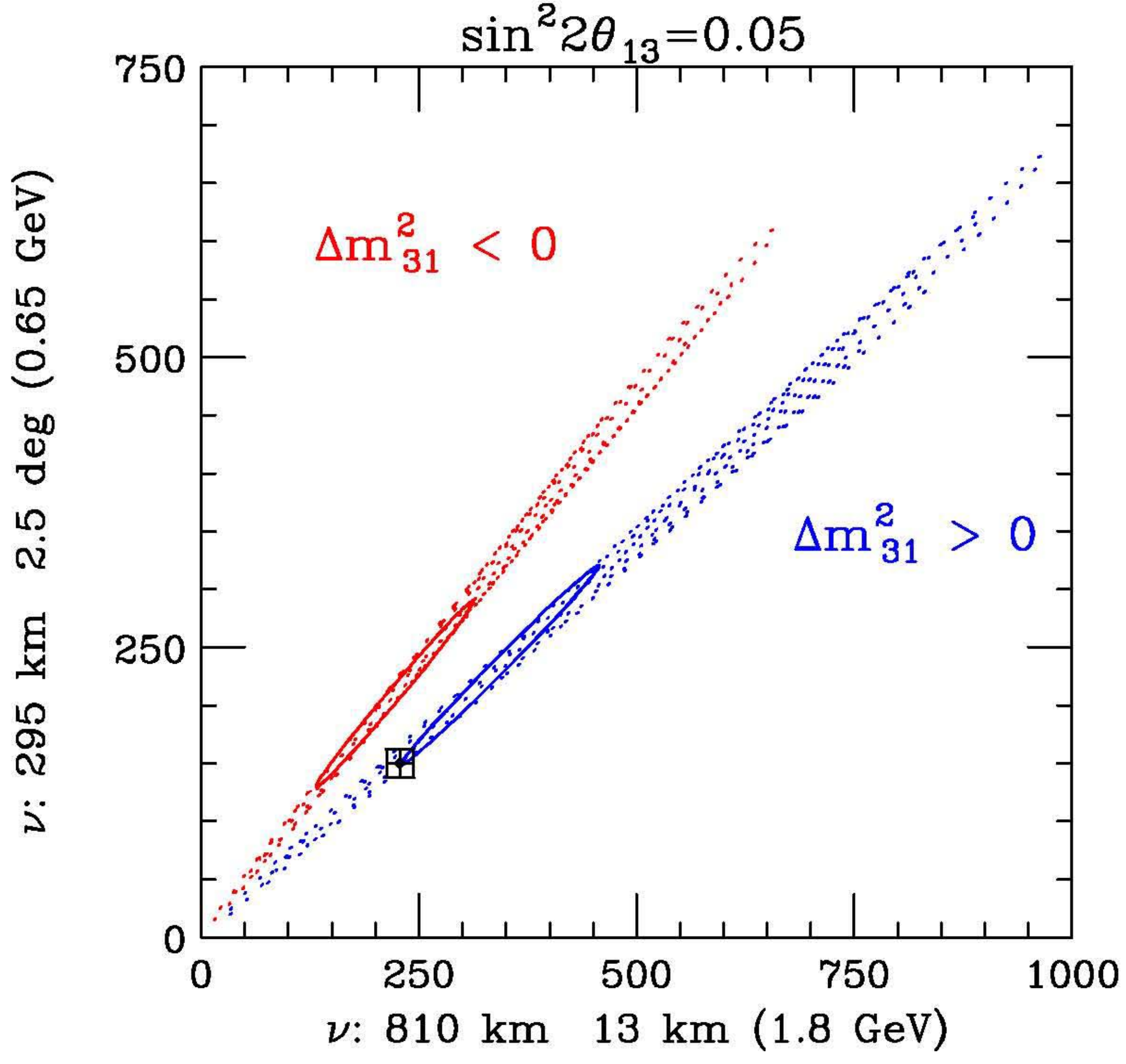
EVENTS T2K (initial) vs. NOVA (initial)



EVENTS T2K (initial) vs. NOVA (intermediate)



EVENTS: T2K (intermediate) vs. NOVA (intermediate)

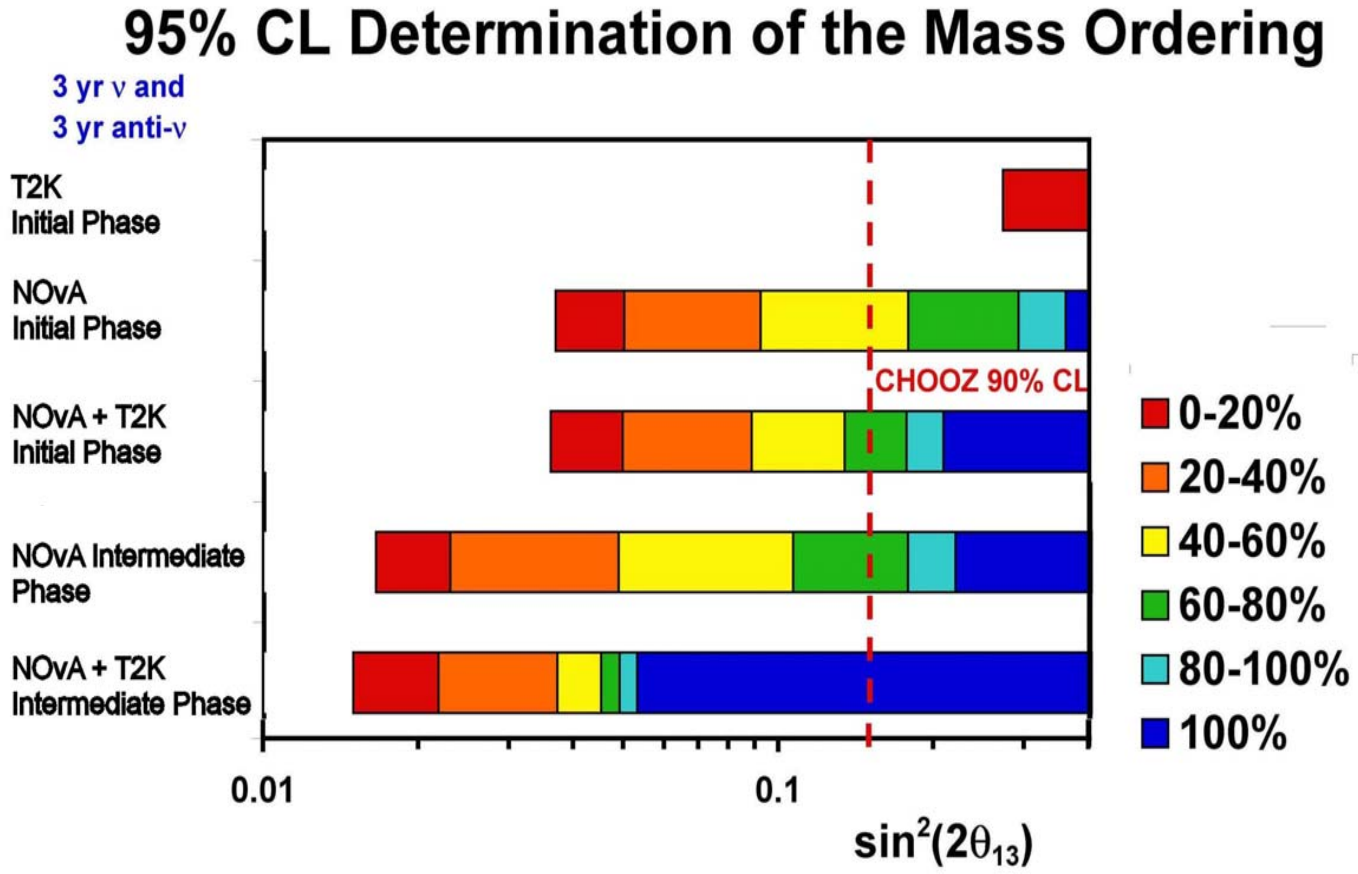


Mass Hierarchy Reach 2010-2020

95 % CL Determination

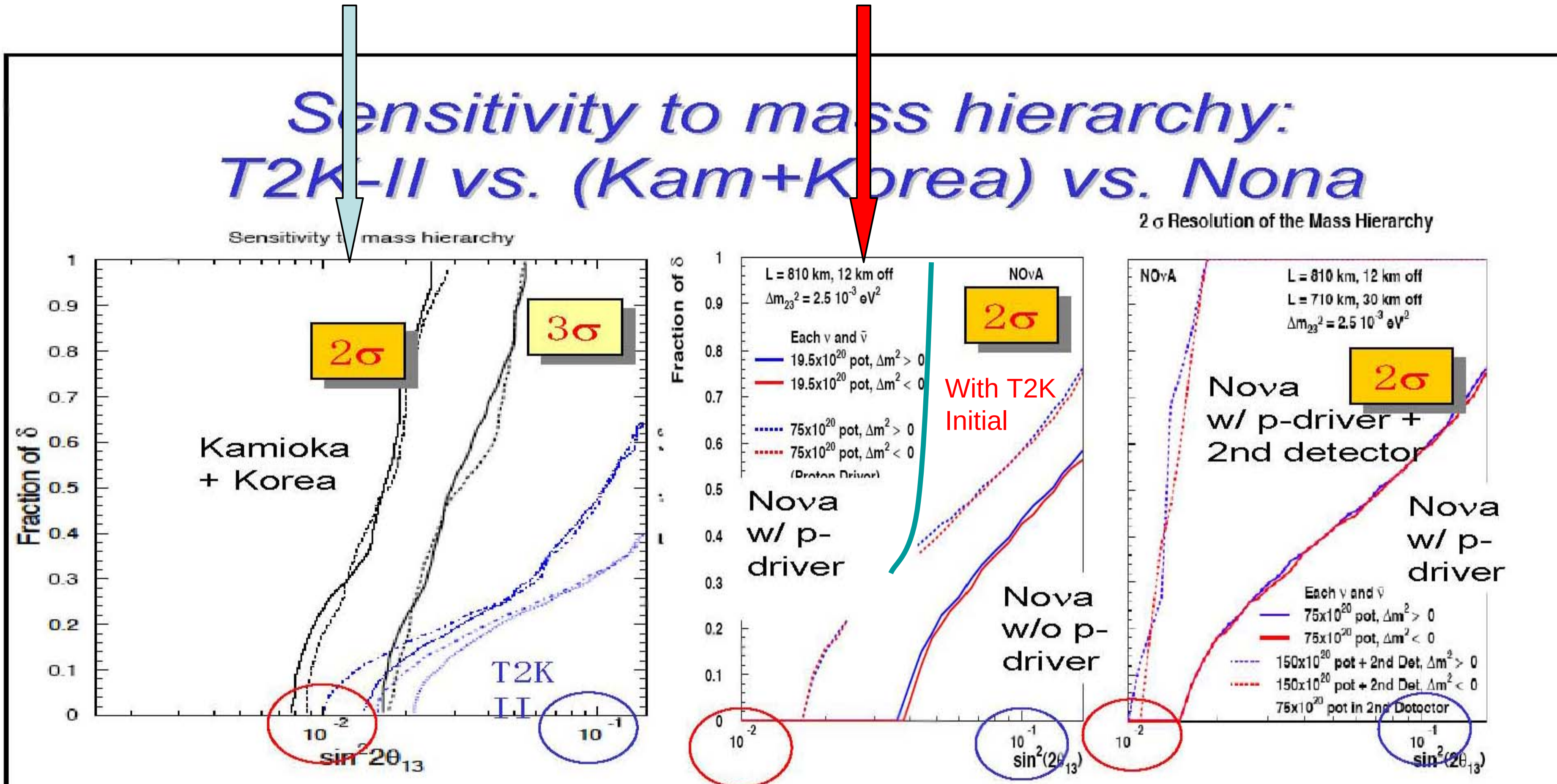
$\sin^2\theta_{13}$	Initial Phase NOVA + 2TK	Intermediate Phase NOVA + T2K
0.12	70%	100%
0.09	40%	100%
0.05	30%	80%
0.03	0%	30%

Reach in parameters possible 2010-2020



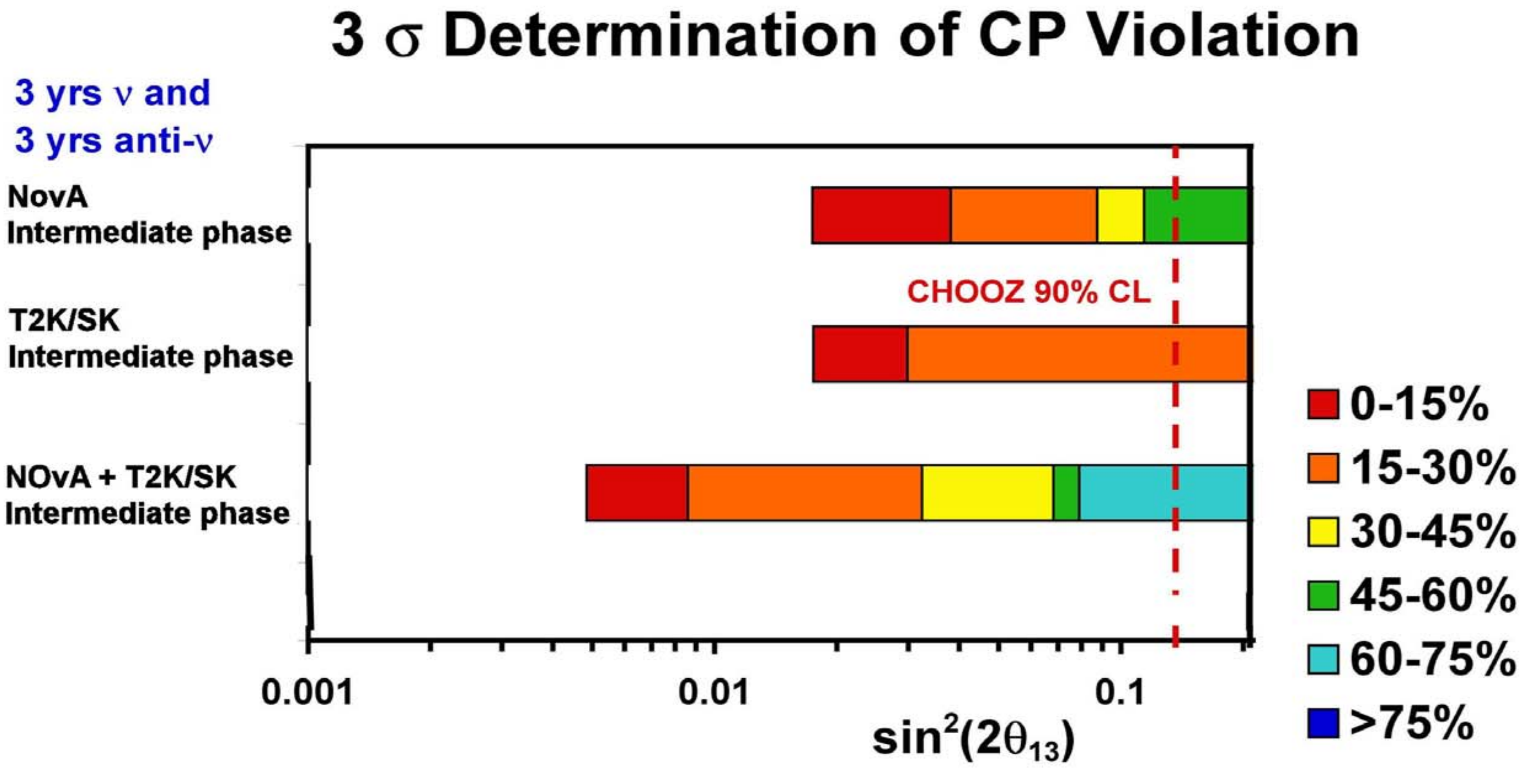
Comparisons 2010-20, 2020-30

The T2K/NOVA intermediate combination is very important
And can be done much earlier as shown in middle graph

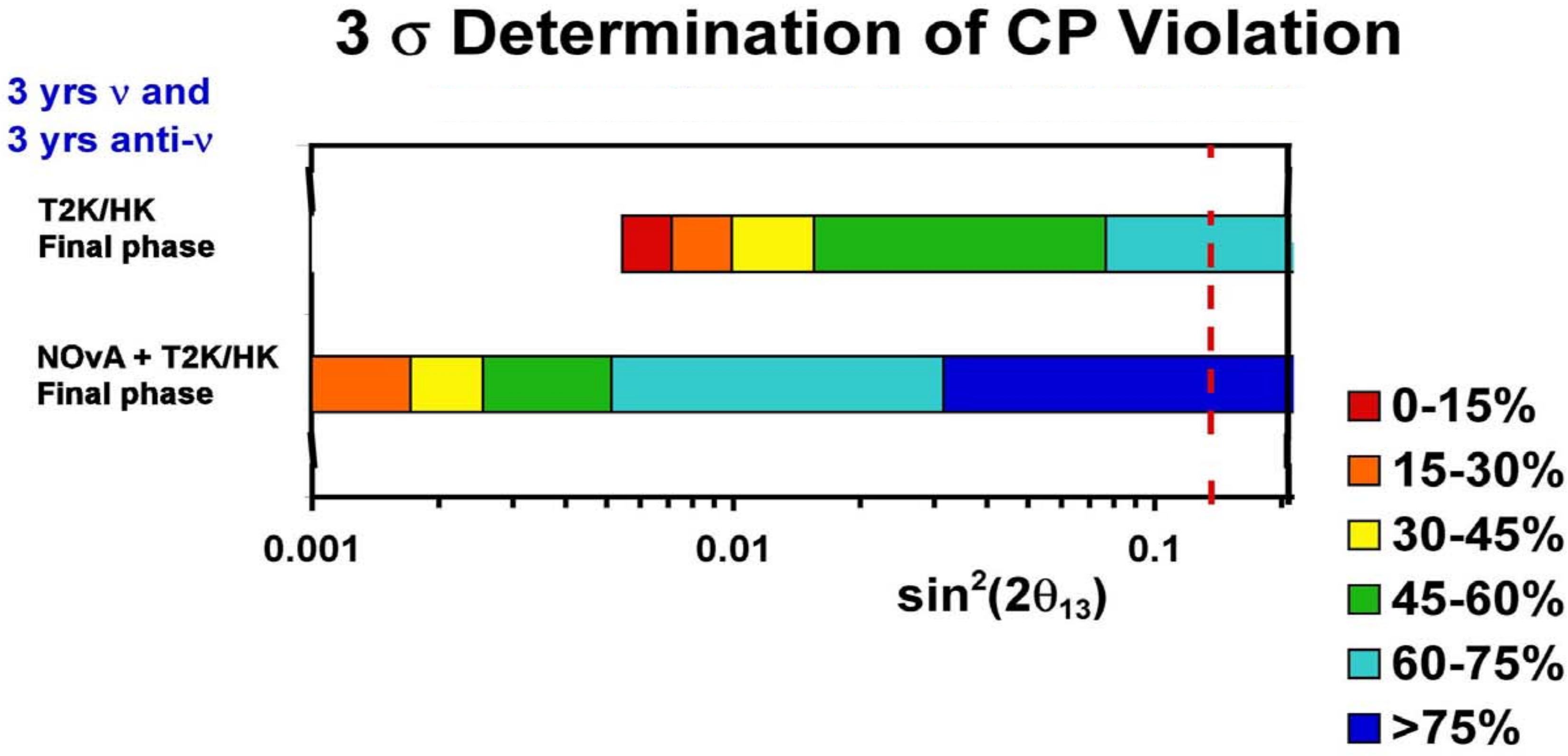


From Kajitasan’s presentation to EPP2010

CP Reach 2010 - 2020



CP Reach final phase 2020-2030



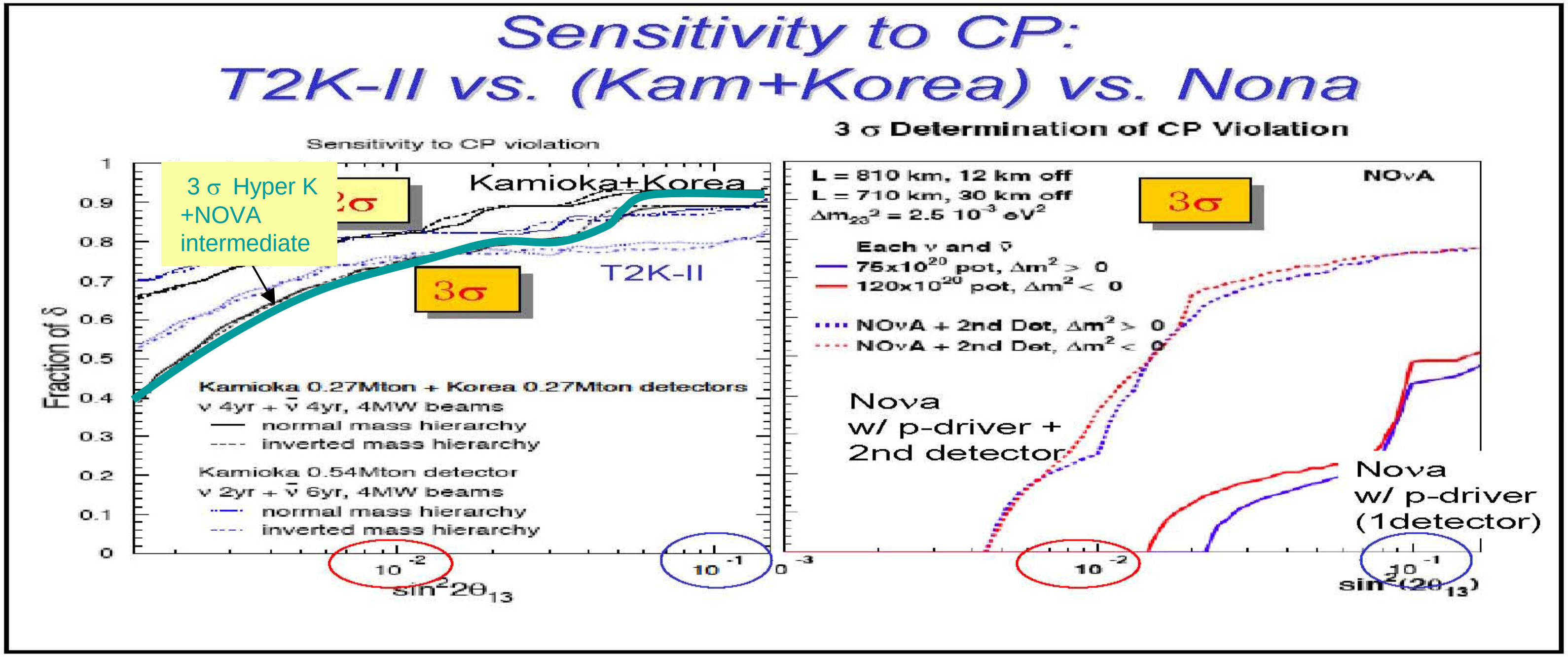
CP Reach 2010 – 2020 and 2020 -2030

Three years of neutrino and three years of antineutrino running

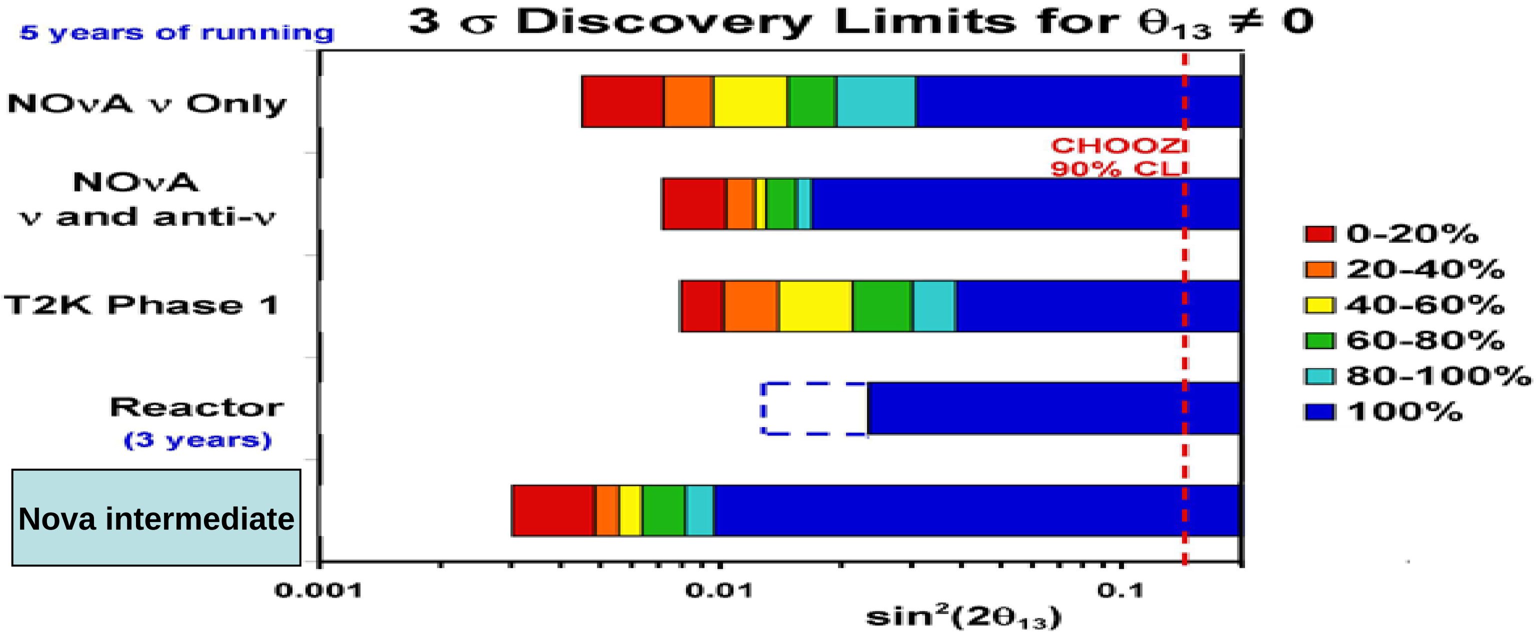
$\sin^2\theta_{13}$	**Intermediate Phase** NOvA + T2K	**Final Phase** NOvA + HK
.12	65%	> 75%
0.09	60%	> 75%
0.06	40%	> 75%
0.03	30%	> 75%
0.01	15%	> 65%

CP reach 2020-30

- Enhanced CP reach with Hyper detectors
- Not much difference between Hyper K and Hyper KK if the mass hierarchy resolved



What if the angle is two small?



Then we will need all the power we can get to push the limit

Conclusion

- NOVA greatly enhances the exploration of neutrino parameters in the era 2010-2020
- To the extend that the Mass Hierarchy is resolved, it allows a much enhanced CP reach for Hyper K in 2020-2030
- The additional reach of Hyper KK relative to NOVA + Hyper K in the mass hierarchy is small (0.03 compared to 0.01 in $\sin^2 2\theta_{13}$).

Topic I

How to capture the ILC: do we maximize the integral probability or the probability of the “golden moment”?

ILC Strategy

- The opportunities at the energy frontier are by far the greatest. Priority of LHC/ILC.
- If the US has no facility at the energy frontier: a much diminished program.
- Therefore, successful bid to host ILC in the US is only second in priority to LHC success.

The golden moment: 2010

- End of the Tevatron and B-factory
- Major redirection is possible
- Strong support from the agency under specified conditions: LHC success, ILC affordable and technically feasible
- Strong support in all regions for an ILC somewhere. Global Design Effort.

Risk

- If we do not move forcefully on ILC R&D, then we risk missing “the golden moment”.

- But, many additional things have to line up for this “golden moment” to be real: risk is multiplied enormously if we only plan for this time frame.

- A strategy that maximizes the overall probability is more desirable, provided the first bullet is satisfied.

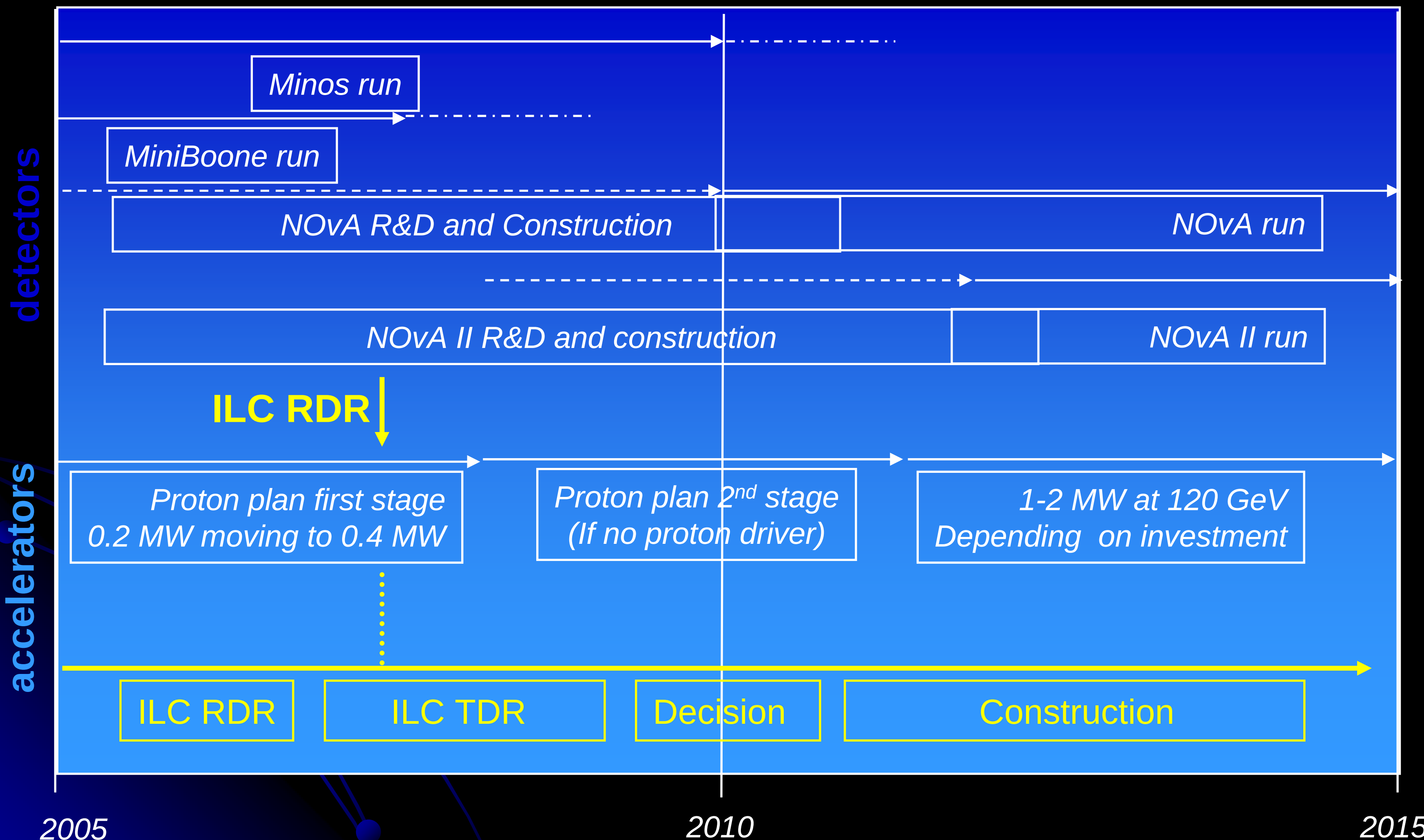
Protecting the flanks

- 1) ILC delay at the end of the decade: we need strong base of accelerator expertise. Neutrino program + R&D.

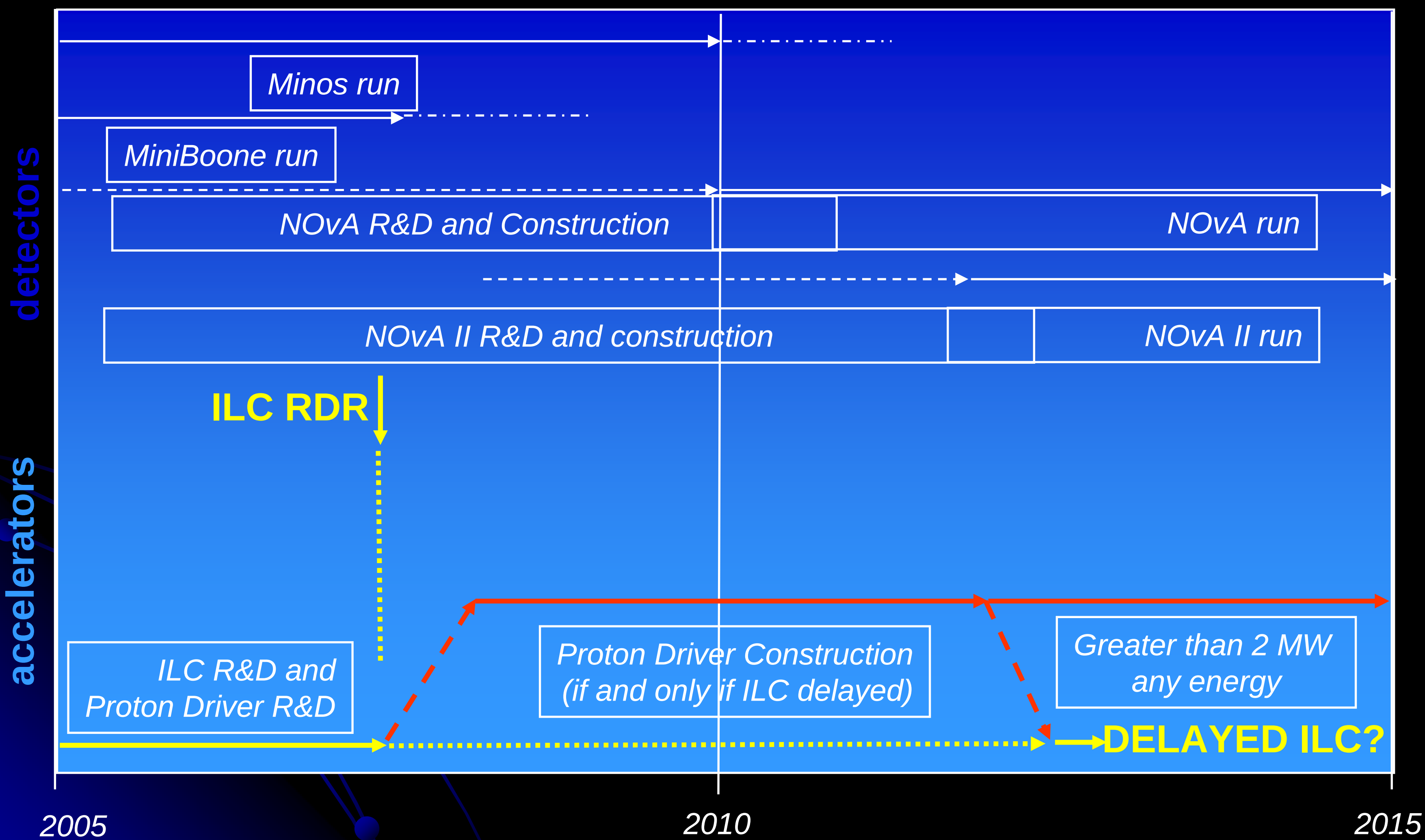
- 2) Cost is too high (RDR end of 2006): back to the drawing board.   Need a vehicle for cheaper and more predictable cost. SCRF Proton Driver.

- 3) If a system's demonstration is necessary (few % of ILC level) : keep proton driver as option.

The world we work for



The world we might be in:



Managing risk: what ifs

- 1) If not enough resources for ILC R&D, do not develop neutrino program.
- 2) In FY2007, if the RDR cost OK, and strong agency support for ILC, all resources headroom goes to ILC (proton driver R&D is put on life support)
- 3) If a system’s demonstration is necessary before construction (few % of ILC level) : evaluate proton driver against other options.

Conclusion

- Our first line of attack is to seek the modest resources necessary to “armor” our strategy. The ILC is likely to be a LONG struggle.
- Only if we fail in that, do we shed further programs to maintain the ILC R&D line alive.
- It is important to determine early if a system demonstration facility is needed.

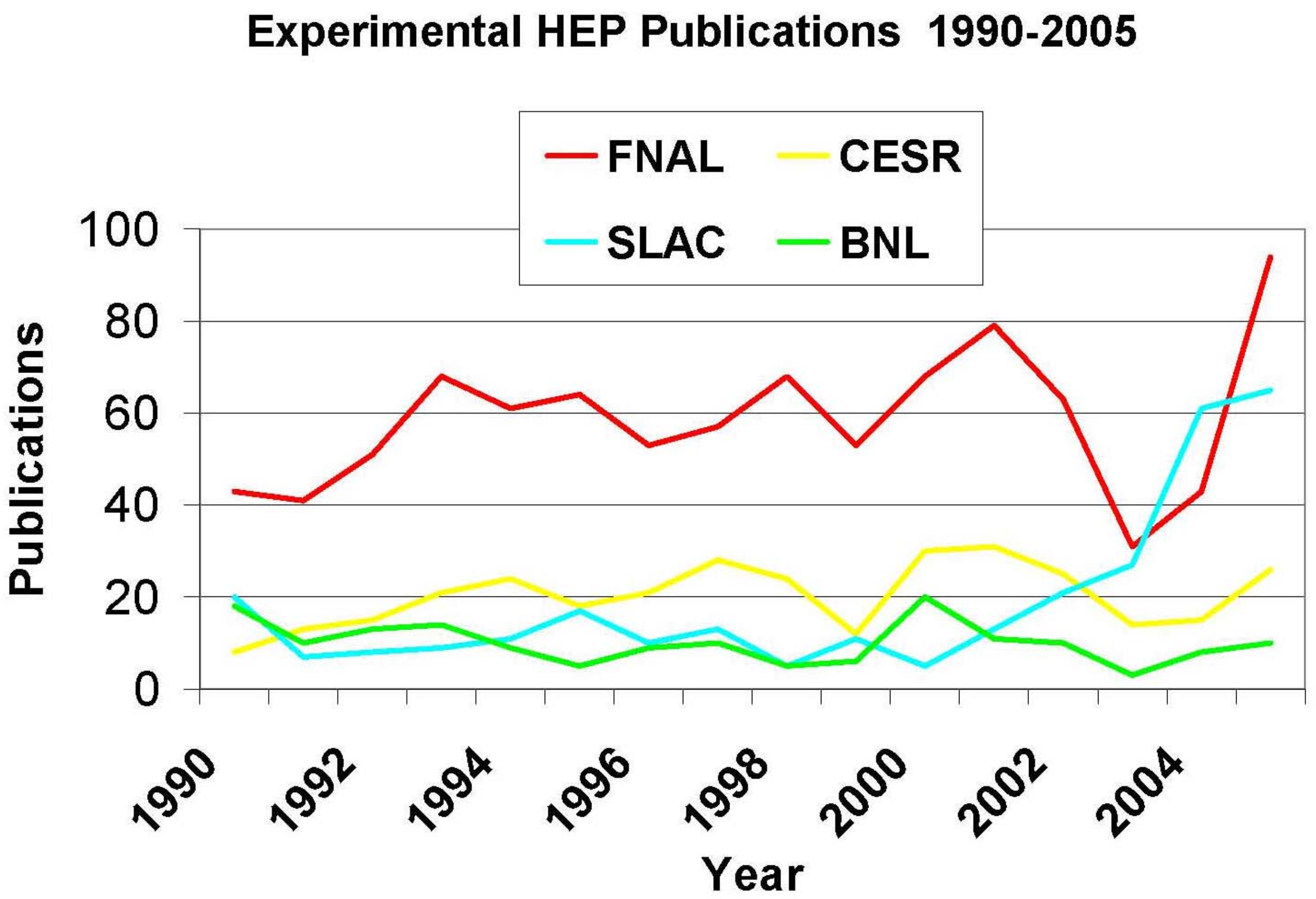
Topic III

Transition at Fermilab: focus, alignment, national involvement, internationalism

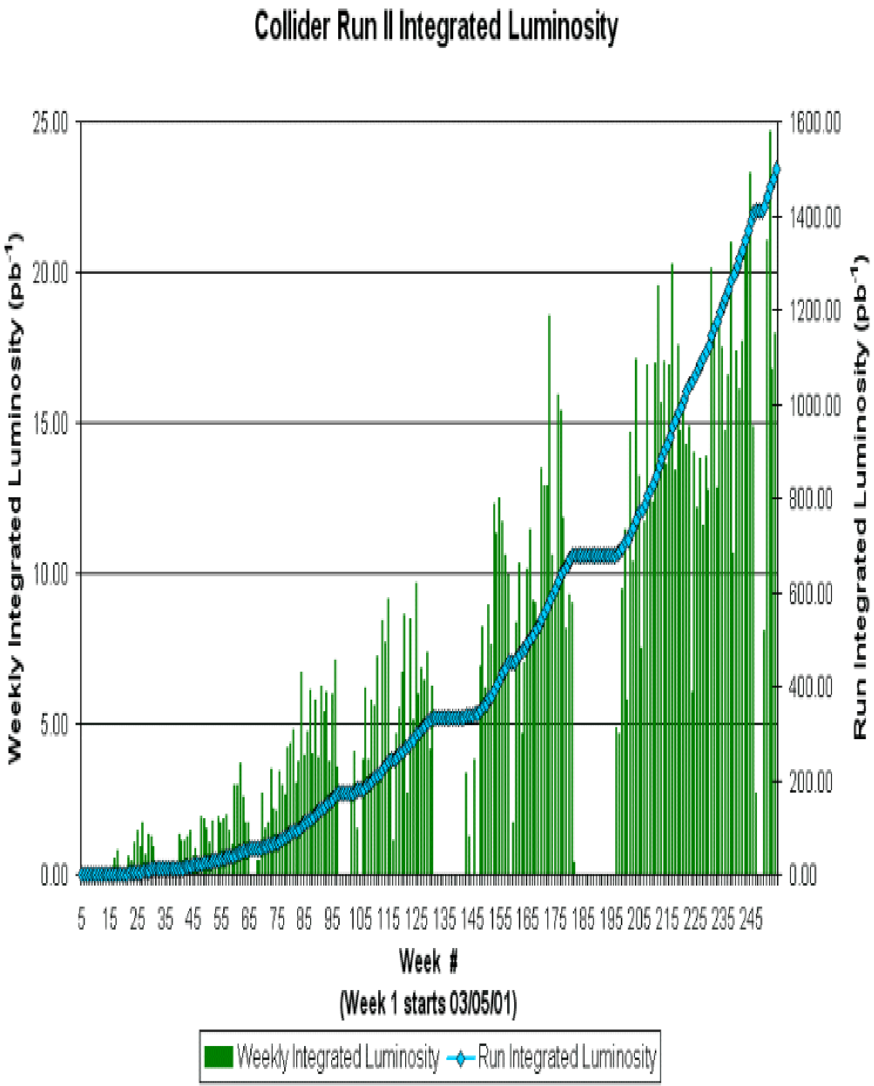
Focus

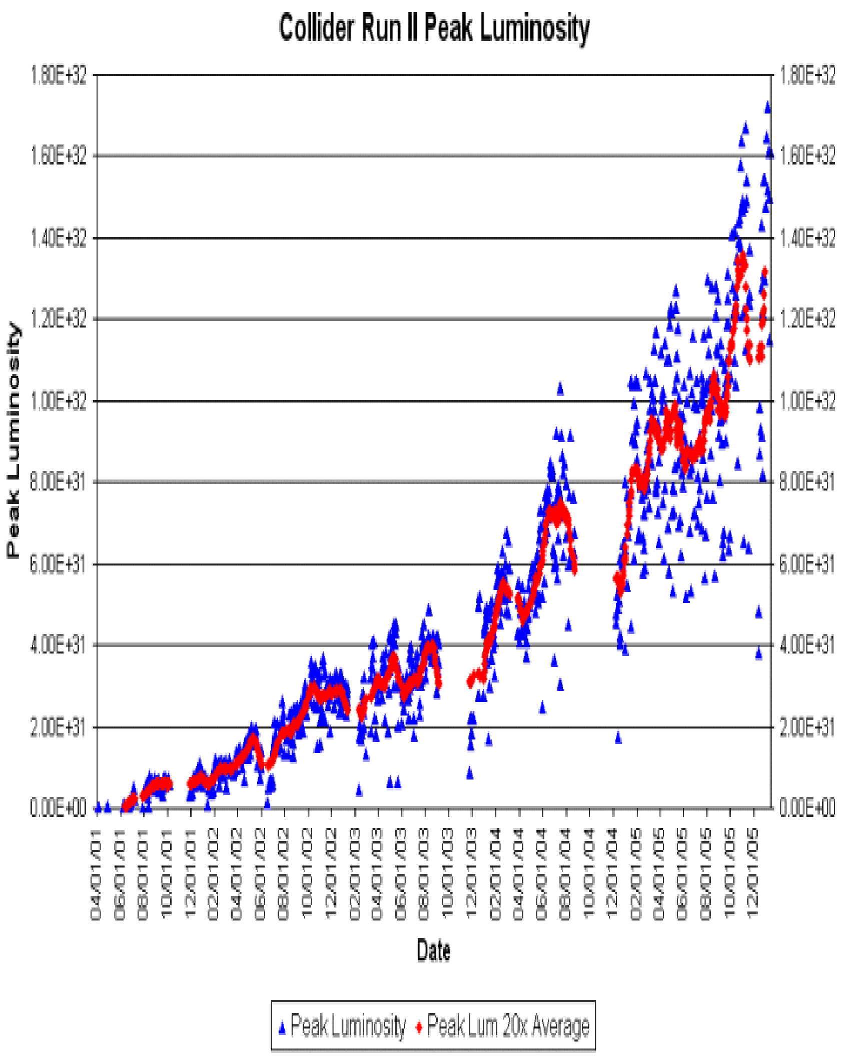
- The laboratory has been and is strongly focused on the Tevatron
- Boundary condition: greatest discovery potential anywhere in the world in the next three years. Do it well or not at all.
- This affects the timing for moving intellectual resources to ILC.
- We have moved some resources, but major move at the end of 2006 when Tevatron upgrades are finished

The physics engines



Tevatron performance





Focus: the Tevatron

- Seven accelerators (or eight with e-cooling)
- Enormous premium on reliability. Roughly 200,000 controllable devices
- Two years training before operators “solo”. Great potential for harm to accelerator components and detectors.
- Fantastic on-the-job training for accelerator physicists. Integral team: physicists, engineers, techs, operators.

Alignment with ILC

- 1% of resources and scientists in FY04 to 10% of total resources and scientists in FY06.
- Need to strengthen specific areas: SCRF expertise
- Intellectual ownership of the machine not there yet: it is well recognized problem and high priority for the lab to remedy.

National involvement

- Must not only build strength at Fermilab as the hub, but must preserve strength/interest at other laboratories. We'll need strong support from other labs that build/run accelerators

- We are planning and working together

- We will exchange personnel initially, and we will do the necessary strategic hires at Fermilab over a longer period of time.

Internationalism

- Detectors: great already.
- Accelerators: very little. Only major contribution from the US is 3% of LHC.
- No investment from abroad in US accelerators.
- ILC is breaking new ground. Everyone on board at this time. Will it remain so after site selection?

Internationalism

- Follow the ILC model for major other components of a world accelerator program: e.g. neutrino factory

- Program coordination in other areas to avoid unessesary duplication.